MARKED-UP VERSION OF ENGLISH TRANSLATION OF INTERNATIONAL APPLICATION AS ORIGINALLY FILED

Attorney Docket No. 36856.1437

~~DESCRIPTION~~

BALANCED-TYPE SURFACE ACOUSTIC WAVE FILTER

BACKGROUND OF THE INVENTION

1. ~~Technical~~ Field of the Invention

[0001] The present invention relates to a balanced-type surface acoustic wave filter provided with a balance-unbalance conversion function, and more particularly, to a balanced-type surface acoustic wave filter in which an IDT has a narrow pitch electrode finger section and ~~at the same time~~ an input/output impedance ratio is set to a specific value.

2. Description of the Related Art

~~Background Art~~

[0002] In the related art, a balanced-type surface acoustic wave filter provided with a balance-unbalance conversion function is widely used in communications equipment, such as mobile phones. For example, Japanese Unexamined Patent Application Publication No. 2001-308672 (Patent Document 1) described below discloses a balanced-type surface acoustic wave filter, which is shown in Fig. 26.

[0003] In a balanced-type surface acoustic wave filter 501 shown in Fig. 26, longitudinally coupled resonator type surface acoustic wave filters 503 and 504 are connected to an

unbalanced input terminal 502. The surface acoustic wave filters 503 and 504 include ~~includes the~~ first to third IDTs (interdigital transducers) 503a to 503c and 504a to 504c arranged in the surface acoustic wave propagating direction, respectively. The second IDTs 503b and 504b in the center are electrically connected to the unbalanced input terminal 502. In~~Then, in~~ the surface acoustic wave propagating direction, the first and third IDTs 503a and 503c arranged on both the sides of the IDT 503b are electrically connected to a first balanced output terminal 505, and ~~. On the other hand,~~ the first and third IDTs 504a and 504c arranged on both the sides of the IDT 504b in the center of the surface acoustic wave filter 504 are electrically connected to a second balanced output terminal 506.

[0004] In the balanced-type surface acoustic wave filter 501, the input impedance on the unbalanced input terminal 502 side is set to 50 Ω, and characteristic impedances on the sides of the first and second balanced output terminals 505 and 506 are set to 150 Ω. That is, the input/output impedance ratio is set to 1:3. This is because an antenna is connected to an input terminal of the balanced-type surface acoustic wave filter 501 and the impedance is usually set to 50 Ω, whereas the input impedance of an IC connected to the output side is set to 150 Ω.

[0005] Japanese Unexamined~~In the meantime,~~ Patent Application Publication No. 6-204781 (Patent Document~~Documents~~ 2) and Japanese Unexamined Patent Application Publication No. 11-97966 (Patent Document 3) described below respectively disclose

balanced-type surface acoustic wave filters provided with a balance-unbalance conversion function similar~~similarly~~ to the balanced-type surface acoustic wave filter described in Patent Document 1, but having ~~being~~ different ~~in~~ electrode configurations.~~constructions.~~ In addition, in the balanced-type surface acoustic wave filters described in Patent Documents 2 and 3~~ as well~~, the impedance ratio between the unbalanced signal terminal and the balanced signal terminal is set to about 1:3 to about 1:4.

[0006] On the other hand, in recent years, a balanced-type mixer IC with an ~~the~~ input impedance of about 100 Ω is commercially available as an IC to be connected to the output side of the balanced-type surface acoustic wave filter of this kind. To cope with such an IC, ~~it is required that~~ the output impedance of the balanced-type surface acoustic wave filter connected to the IC must be~~is~~ set to about 100 Ω. Then, to set the impedance on the input terminal side to 50 Ω, an input/output impedance ratio of the surface acoustic wave filter is required to be 1:2.

[0007] Japanese Unexamined Patent Application Publication No. 2004-48675 (Patent Document ~~Documents~~ 4) described below discloses a balanced-type surface acoustic wave filter provided with a balance-unbalance conversion function in which the impedance ratio between an unbalanced signal terminal and a balanced signal terminal is set to 1:2. Fig. 27 is a plan view showing the electrode configuration~~construction~~ of the balanced-

type surface acoustic wave filter described in Patent Document ~~Documents~~ 4. In a balanced-type surface acoustic wave filter 601, connected to an unbalanced input terminal 602 are longitudinally coupled resonator type surface acoustic wave filter sections 603 and 604. The longitudinally coupled resonator type surface acoustic wave filter sections 603 and 604 respectively include ~~the~~ first to third IDTs 603a to 603c and 604a to 604c arranged in the surface acoustic wave propagating direction. The IDTs 603b and 604b in the center are electrically connected to the unbalanced input terminal 602. The first and third IDTs ~~IDT~~ 603a and 603c located on both the sides of the surface acoustic wave propagating direction of the IDT 603b are electrically connected to a first balanced output terminal 605. In the same manner, in surface acoustic wave filter section 604, the IDTs ~~IDT~~ 604a, 604c located on both the sides of the IDT 604b in the surface acoustic wave propagating direction are electrically connected to the second balanced output terminals 606.

[0008] Here, the IDTs ~~IDT~~ 603a and 603b include narrow pitch electrode finger sections N in the neighborhood of the areas adjacent to each other with a gap interposed therebetween in the surface acoustic wave propagating direction. That is, the electrode finger pitch of the area of IDT 603a near the IDT 603b has a narrower electrode finger pitch as compared to the rest of the areas. This IDT area where the electrode finger pitch is relatively narrow is referred to as a narrow pitch electrode finger section N. In the same manner, the area of IDT 603b near

the IDT 603a at the side end is provided with a~~the~~ narrow pitch electrode finger section N. Furthermore, in the IDTs 603b and 603c and IDTs 604a to 604c as well, the respective neighborhoods of the adjacent areas with the gap are provided with the narrow pitch electrode finger section N.

~~Then,~~ Patent Document 4 also describes that in the balanced-type surface acoustic wave filter 601, the IDTs ~~IDT~~ 603b and 604b on the unbalanced side and the IDTs 603a, 603c, 604a, and 604c on the balanced side are set to have different numbers~~logs~~ of the electrode fingers, whereby the input/output impedance ratio can be set to 1:2.

~~Patent Document 1: Japanese Unexamined Patent Application Publication No. 2001-308672~~

~~Patent Document 2: Japanese Unexamined Patent Application Publication No. 6-204781~~

~~Patent Document 3: Japanese Unexamined Patent Application Publication No. 11-97966~~

~~Patent Document 4: Japanese Unexamined Patent Application Publication No. 2004-48675~~

~~Disclosure of Invention~~

[0009] In the surface acoustic wave filter, the impedance of the IDT decreases~~becomes smaller~~ as an electrode finger cross width is increased~~larger~~ and the number of electrode fingers is increased.~~larger.~~ In the surface acoustic wave filter 601 shown in Fig. 25, for example, the IDT 603b in the center of the surface acoustic wave filter section 603 is connected to the

unbalanced input terminal 602, the IDTs 603a and 603c on both the sides are connected to the first balanced output terminal 605.

[0010] Therefore, to adjust the impedance ratio between the unbalanced signal terminal and the balanced signal terminal, the cross width of the IDT 603b and the cross widths of the IDTs 603a and 603c cannot be ~~set~~ different from one another. Therefore, as described above, the number~~log~~ of the electrode fingers of the IDT 603b on the unbalanced side and the numbers~~logs~~ of the electrode fingers of the IDTs 603a and 603c on the balanced side are made different from each other, and the input/output impedance ratio is changed. For example, the impedance of the first balanced output terminal is~~becomes~~ a value depending on the number~~log~~ of the electrode fingers of the IDT 603a on the balanced side. This is because~~,~~ the IDTs 603a and 603c are connected in parallel with respect to a balanced output terminal ~~terminals~~ 605 and at the same time the balanced output terminal 605 and the balanced output terminal 606 are connected in series via a ground~~an earth~~ potential. In contrast~~contract~~ to this, the impedance of the unbalanced terminal 602 side has a value corresponding to 1/2 of the number~~log~~ of the electrode fingers of the IDT 603b on the unbalanced side. That is, when the number~~log~~ of the electrode fingers of the IDT 603b on the unbalanced side is set to 1/2 of the number~~log~~ of the electrode fingers of the IDT 603a on the balanced side, the impedance ratio between the unbalanced signal terminal and the balanced signal terminal can be set to 1:2~~.~~

[0011] ~~——~~However, the ratio between the numbers~~logs~~ of the IDT 603b and 604b on the unbalanced side and the numbers~~logs~~ of the IDTs 603a, 603c, 604a, and 604c on both ~~the~~ sides thereof is changed, and a problem occurs in that an influence is imparted to resonant frequencies of a plurality of resonant modes for obtaining a pass band of the surface acoustic wave filter 601. Thus, the number~~log~~ ratio cannot be ~~changed~~ significantly changed. Since ~~. Then, as~~ the number~~log~~ of the IDT on the unbalanced side is much less~~smaller~~ than the numbers~~logs~~ of the IDTs 603a and 603c on the balanced side, there is also a problem in that a ~~the~~ sufficient band width of ~~as~~ a filter cannot be obtained.

[0012] ~~——~~In addition, with a method of changing the ratio between the numbers~~logs~~ of the electrode fingers, the impedance ratio between the unbalanced signal terminal and the balanced signal terminal cannot be precisely set to 1:2~~ with precision~~, and the set ratio is often shifted from 1:2.

SUMMARY OF THE INVENTION

[0013] In order ~~—— An object of the present invention is~~ to overcome~~eliminate~~ the problems described above, preferred embodiments of the present invention ~~-mentioned drawbacks of the related art and to~~ provide a surface acoustic wave filter provided with a balance-unbalance conversion function, in which the degree of freedom for adjusting impedances of a plurality of resonant modes for obtaining a pass band is ~~can be~~ increased without degrading filter characteristics, such as a band width

and a loss, and accordingly, ~~it is possible to easily set~~ the impedance ratio between the unbalanced signal terminal and the balanced signal terminal can be easily precisely set to 1:2 or other desired ratios, and, in addition, a ~~the like with precision, and also a~~ sufficient band width is obtained.

[0014] A first preferred embodiment of the present invention ~~of this application~~ is a balanced-type surface acoustic wave filter connected to an unbalanced terminal and first and second balanced terminals and provided with a balance-unbalance conversion function, including~~:~~ a piezoelectric substrate,~~;~~ a first surface acoustic wave filter section including first to third IDTs arranged along a surface acoustic wave propagating direction on the piezoelectric substrate, the second IDT in the center or the first and third IDTs on both ~~the~~ sides of the second IDT being connected to the unbalanced terminal, and the first and third IDTs on both ~~the~~ sides of the second IDT or the second IDT in the center being connected to the first balanced terminal,~~;~~ and a second surface acoustic wave filter section including first to third IDTs arranged in the surface acoustic wave propagating direction on the piezoelectric substrate, the second IDT in the center or the first and third IDTs on both ~~the~~ sides of the second IDT being connected to the unbalanced terminal, the first and third IDTs on both ~~the~~ sides of the second IDT or the second IDT in the center being connected to the second balanced terminal, and the second surface acoustic wave filter section being arranged~~constructed~~ to have a phase of an

output signal to an input signal different by about 180 degrees with respect to the first surface acoustic wave filter section, wherein~~the balanced-type surface acoustic wave filter being characterized in that~~ in the first and second surface acoustic wave filter sections, in a pair of IDTs adjacent to each other with a gap interposed therebetween in the surface acoustic wave propagating direction, a section where a cycle of a portion~~part~~ of electrode fingers including an electrode finger facing the gap is less~~smaller~~ than a cycle of electrode fingers of a main portion~~part~~ of the IDT is set as a narrow pitch electrode finger section. When~~, and when~~ an electrode finger pitch of the narrow pitch electrode finger section of the IDT connected to the unbalanced terminal of the first and second surface acoustic wave filter sections is set as P1, an electrode finger pitch of the narrow pitch electrode finger section of the IDT connected to the balanced terminal is set as P2, the number of electrode fingers of the pitch electrode finger section except for the narrow pitch electrode finger section of the IDT connected to the unbalanced terminal of the first and second surface acoustic wave filter sections is set as K1, and the number of electrode fingers of the pitch electrode finger section except for the narrow pitch electrode finger section of the IDT connected to the balanced terminal is set as K2, the following relationships:

$P1>P2$; and

$1.12 \le K1/K2 \le 1.65$

are satisfied.

[0015] A second preferred embodiment~~invention~~ is a balanced-type surface acoustic wave filter connected to an unbalanced terminal and first and second balanced terminals and provided with a balance-unbalance conversion function, including~~:~~ a piezoelectric substrate,~~;~~ a first surface acoustic wave filter section including first to third IDTs arranged along a surface acoustic wave propagating direction on the piezoelectric substrate, the second IDT in the center or the first and third IDTs on both ~~the~~ sides of the second IDT being connected to the unbalanced terminal and the first and third IDTs on both ~~the~~ sides of the second IDT or the second IDT in the center being connected to the first balance terminal,~~;~~ and a second surface acoustic wave filter section including first to third IDTs arranged in the surface acoustic wave propagating direction on the piezoelectric substrate, the second IDT in the center or the first and third IDTs on both ~~the~~ sides of the second IDT being connected to the unbalanced terminal, the first and third IDTs on both ~~the~~ sides of the second IDT or the second IDT in the center being connected to the second balanced terminal, and the second surface acoustic wave filter section being arranged~~constructed~~ to have a phase of an output signal to an input signal different by about 180 degrees with respect to the first surface acoustic wave filter section, wherein~~the balanced-type surface acoustic wave filter being characterized in that~~ in the first and second surface acoustic wave filter sections, in a pair of IDTs adjacent to each other with a gap interposed therebetween in the surface

acoustic wave propagating direction, a section where a cycle of a portion~~part~~ of electrode fingers including an electrode finger facing the gap is less~~smaller~~ than a cycle of electrode fingers of a main portion~~part~~ of the IDT is set as a narrow pitch electrode finger section. When~~, and when~~ an electrode finger pitch of the narrow pitch electrode finger section of the IDT connected to the unbalanced terminal of the first and second surface acoustic wave filter sections is set as P1, an electrode finger pitch of the narrow pitch electrode finger section of the IDT connected to the balanced terminal is set as P2, the number of electrode fingers of the pitch electrode finger section except for the narrow pitch electrode finger section of the IDT connected to the unbalanced terminal of the first and second surface acoustic wave filter sections is set as K1, the number of electrode fingers of the pitch electrode finger section except for the narrow pitch electrode finger section of the IDT connected to the balanced terminal is set as K2, the number of electrode fingers of the narrow pitch electrode finger section of the IDT connected to the unbalanced terminal of the first and second surface acoustic wave filter sections is set as K1n, and the number of electrode fingers of the narrow pitch electrode finger section of the IDT connected to the balanced terminal is set as K2n, the following relationships:

$P1>P2$;

$K1n=K2n$; and

$1.12 \leq K1/K2 \leq 1.65$

are satisfied.

[0016] In the balanced-type surface acoustic wave filters according to the first and second preferred embodiments~~inventions~~, preferably, when a metallization ratio in the first and second surface acoustic wave filter sections is set as d and an electrode finger cross width is set as W, 67.4 λI≤W/d≤74.3 λI (where λI denotes a wavelength of the IDT) is satisfied.

[0017] A third preferred embodiment~~invention of this application~~ is a balanced-type surface acoustic wave filter connected to a balanced terminal and first and second unbalanced terminals and provided with a balance-unbalance conversion function, including~~:~~ a piezoelectric substrate,~~;~~ and first to third IDTs arranged in a surface acoustic wave propagating direction on the piezoelectric substrate, wherein~~the balanced-type surface acoustic wave filter being characterized in that~~ the second IDT is connected to the unbalanced terminal, and the first and third IDTs on both ~~the~~ sides of the second IDT are respectively connected to the first and second balanced terminals, and in an area where the first to third IDTs are adjacent to one another, the respective IDTs have narrow pitch electrode finger sections and an electrode finger pitch of the narrow pitch electrode finger section is less~~set smaller~~ than an electrode finger pitch of a main portion~~part~~ of the pitch electrode finger section of the IDT provided with narrow pitch electrode fingers, and a phase of the first IDT is reversed by about 180 degrees with respect to a phase of the third IDT, and when an electrode

finger pitch of the narrow pitch electrode finger section of the second IDT located in the center is set as P1, an electrode finger pitch of the narrow pitch electrode finger section of the first and third IDTs is set as P2, the number of electrode fingers of the pitch electrode finger section except for the narrow pitch electrode finger section of the second IDT is set as K1, and the number of electrode fingers of the pitch electrode finger section except for the narrow pitch electrode finger section of the first and third IDTs is set as K2, the following relationships:

$P1>P2$; and

$1.12 \leq K1/K2 \leq 1.65$

are satisfied.

[0018] A fourth preferred embodiment~~invention~~ is a balanced-type surface acoustic wave filter connected to a balanced terminal and first and second unbalanced terminals and provided with a balance-unbalance conversion function, including~~:~~ a piezoelectric substrate,~~;~~ and first to third IDTs arranged in a surface acoustic wave propagating direction on the piezoelectric substrate, wherein~~the balanced-type surface acoustic wave filter being characterized in that~~ the second IDT is connected to the unbalanced terminal, the first and third IDTs on both ~~the~~ sides of the second IDT are respectively connected to the first and second balanced terminals, and in an area where the first to third IDTs are adjacent one another, the respective IDTs have narrow pitch electrode finger sections and an electrode finger

pitch of the narrow pitch electrode finger section is less~~set smaller~~ than an electrode finger pitch of a main portion~~part~~ of the pitch electrode finger section of the IDT provided with narrow pitch electrode fingers, and a phase of the first IDT is reversed by about 180 degrees with respect to a phase of the third IDT, and when an electrode finger pitch of the narrow pitch electrode finger section of the second IDT located in the center is set as P1, an electrode finger pitch of the narrow pitch electrode finger section of the first and third IDTs is set as P2, the number of electrode fingers of the pitch electrode finger section except for the narrow pitch electrode finger section of the second IDT is set as K1, the number of electrode fingers of the pitch electrode finger section except for the narrow pitch electrode finger section of the first and third IDTs is set as K2, the number of electrode fingers of the narrow pitch electrode finger section of the second IDT is set as K1n, the number of electrode fingers of the narrow pitch electrode finger section of the first and third IDTs is set as K2n, the following relationships:

$P1>P2$;

$K1n=K2n$; and

$1.12 \le K1/K2 \le 1.65$

are satisfied.

[0019] In the balanced-type surface acoustic wave filters according to the third and fourth preferred embodiments~~inventions~~, preferably, when a metallization ratio in the first to third IDTs

is set as d and an electrode finger cross width is set as W, 134.8 $\lambda I \leq W/d \leq 148.6 \lambda I$ (where λI denotes a wavelength of the IDT) is satisfied.

[0020] A fifth preferred embodiment~~invention~~ is a balanced-type surface acoustic wave filter connected to an unbalanced terminal and first and second balanced terminals and provided with a balance-unbalance conversion function, including~~:~~ a piezoelectric substrate,~~;~~ and first to third IDTs arranged in a surface acoustic wave propagating direction on the piezoelectric substrate, wherein ~~the balanced-type surface acoustic wave filter being characterized in that~~ the first and third IDTs located on both ~~the~~ sides of the second IDT in the surface acoustic wave propagating direction are connected to the unbalanced terminal, the second IDT includes first and second IDT sections divided in the surface acoustic wave propagating direction and the first and second IDT sections are respectively electrically connected to the first and second balanced signal terminals, the first to third IDTs are arranged such that ~~constructed to set~~ a phase of a signal emanating from the unbalanced terminal to the first balanced signal terminal is reversed by about 180 degrees with respect to a phase of a signal emanating from the unbalanced terminal to the second balanced signal terminal, and in an area where the first to third IDTs are adjacent one another in the surface acoustic wave propagating direction with a gap interposed therebetween, a plurality of electrode fingers near the gap correspond to a narrow pitch electrode finger section in

which~~where~~ a pitch of the electrode fingers is relatively small, and when an electrode finger pitch of the narrow pitch electrode finger section of the first and third IDTs connected to the unbalanced signal terminal is set as P1, an electrode finger pitch of the narrow pitch electrode finger section of the second IDT whose first and second IDT sections are respectively connected to the first and second balanced signal terminal is set as P2, the number of electrode fingers of the pitch electrode finger section except for the narrow pitch electrode finger section of the first and third IDTs is set as K1, and the number of electrode fingers of the pitch electrode finger section except for the narrow pitch electrode finger section of the second IDT is set as K2, the following relationships:

$P1>P2$; and

$1.12 \le K1/K2 \le 1.65$

are satisfied.

[0021] A sixth preferred embodiment~~invention~~ is a balanced-type surface acoustic wave filter connected to an unbalanced terminal and first and second balanced terminals and provided with a balance-unbalance conversion function, including~~:~~ a piezoelectric substrate,~~;~~ and first to third IDTs arranged in a surface acoustic wave propagating direction on the piezoelectric substrate, wherein ~~the balanced-type surface acoustic wave filter being characterized in that~~ the first and third IDTs located on both ~~the~~ sides of the second IDT in a surface acoustic wave propagating direction are connected to the unbalanced terminal,

the second IDT includes first and second IDT sections divided in the surface acoustic wave propagating direction and the first and second IDT sections are respectively electrically connected to the first and second balanced signal terminals, the first to third IDTs are <u>arranged such that</u> ~~constructed to set~~ a phase of a signal emanating from the unbalanced terminal to the first balanced signal terminal <u>is</u> reversed by <u>about</u> 180 degrees with respect to a phase of a signal emanating from the unbalanced terminal to the second balanced signal terminal, and in an area where the first to third IDTs are adjacent one another in the surface acoustic wave propagating direction with a gap interposed therebetween, a plurality of electrode fingers near the gap correspond to a narrow pitch electrode finger section where a pitch of the electrode fingers is relatively small, and when an electrode finger pitch of the narrow pitch electrode finger section of the first and third IDTs connected to the unbalanced signal terminal is set as P1, an electrode finger pitch of the narrow pitch electrode finger section of the second IDT whose first and second IDT sections are respectively connected to the first and second balanced signal terminal is set as P2, the number of electrode fingers of the pitch electrode finger section except for the narrow pitch electrode finger section of the first and third IDTs is set as K1, the number of electrode fingers of the pitch electrode finger section except for the narrow pitch electrode finger section of the second IDT is set as K2, the number of electrode fingers of the narrow pitch electrode finger

section of the first and third IDTs is set as K1n, and the number of electrode fingers of the narrow pitch electrode finger section of the second IDT is set as K2n, the following relationships:

$P1>P2$;

$K1n=K2n$; and

$1.12 \le K1/K2 \le 1.65$

are satisfied.

[0022] In the balanced-type surface acoustic wave filters according to the fifth and sixth preferred embodiments~~inventions~~, preferably, when a metallization in the first to third IDTs is set as d and an electrode finger cross width is set as W, $134.8\ \lambda I \le W/d \le 148.6\ \lambda I$ (where λI denotes a wavelength of the IDT) is satisfied.

[0023] A seventh preferred embodiment~~invention of this application~~ is a balanced-type surface acoustic wave filter connected to an unbalanced terminal and first and second balanced terminals and provided with a balance-unbalance conversion function, including~~:~~ a piezoelectric substrate,~~;~~ a first surface acoustic wave filter section including first to third IDTs arranged along a surface acoustic wave propagating direction on the piezoelectric substrate, the second IDT in the center or the first and third IDTs on both ~~the~~ sides of the second IDT being connected to the unbalanced terminal, and the first and third IDTs on both ~~the~~ sides of the second IDT or the second IDT in the center being connected to the first balanced terminal,~~;~~ and a second surface acoustic wave filter section including first to

third IDTs arranged in the surface acoustic wave propagating direction on the piezoelectric substrate, the second IDT in the center or the first and third IDTs on both ~~the~~ sides of the second IDT being connected to the unbalanced terminal, the first and third IDTs on both ~~the~~ sides of the second IDT or the second IDT in the center being connected to the second balanced terminal, and the second surface acoustic wave filter section being arranged~~constructed~~ to have a phase of an output signal to an input signal different by about 180 degrees with respect to the first surface acoustic wave filter section, wherein~~the balanced-type surface acoustic wave filter being characterized in that~~ in the first and second surface acoustic wave filter sections, in a pair of IDTs adjacent to each other with a gap interposed therebetween in the surface acoustic wave propagating direction, a section where a cycle of a portion~~part~~ of electrode fingers including an electrode finger facing the gap is less~~smaller~~ than a cycle of electrode fingers of a main portion~~part~~ of the IDT is set as a narrow pitch electrode finger section, and when an electrode finger pitch of the narrow pitch electrode finger section of the IDT connected to the unbalanced terminal of the first and second surface acoustic wave filter sections is set as P1, the number of electrode fingers of the narrow pitch electrode finger section thereof is set as N1, an electrode finger pitch of the narrow pitch electrode finger section of the IDT connected to the first and second balanced terminals is set as P2, and the number of electrode fingers of the narrow pitch electrode finger

section thereof is set as N2, the following relationships:

$P1 \neq P2$; and

$N1 < N2$

are satisfied.

[0024] ~~——~~An eighth preferred embodiment~~invention~~ is a balanced-type surface acoustic wave filter connected to a balanced terminal and first and second unbalanced terminals and provided with a balance-unbalance conversion function, including~~:~~ a piezoelectric substrate,~~;~~ and first to third IDTs arranged in a surface acoustic wave propagating direction on the piezoelectric substrate, wherein~~the balanced-type surface acoustic wave filter being characterized in that~~ the second IDT is connected to the unbalanced terminal, and the first and third IDTs are respectively connected to the first and second balanced terminals, and in an area where the first to third IDTs are adjacent one another, the respective IDTs have narrow pitch electrode finger sections and an electrode finger pitch of the narrow pitch electrode finger section is less~~set smaller~~ than an electrode finger pitch of a main portion~~part~~ of the pitch electrode finger section of the IDT provided with narrow pitch electrode fingers, and a phase of the first IDT is reversed by about 180 degrees with respect to a phase of the third IDT, and when an electrode finger pitch of the narrow pitch electrode finger section of the second IDT connected to the unbalanced terminal is set as P1, the number of electrode fingers of the narrow pitch electrode finger section thereof is set as N1, an electrode finger pitch of the

narrow pitch electrode finger section of the first and third IDTs connected to the first and second balanced terminals is set as P2, and the number of electrode fingers of the narrow pitch electrode finger section thereof is set as N2, the following relationships:

$P1 \neq P2$; and

$N1 < N2$

are satisfied.

[0025] A ninth preferred embodiment~~invention~~ is a balanced-type surface acoustic wave filter connected to an unbalanced terminal and first and second balanced terminals and provided with a balance-unbalance conversion function, including~~:~~ a piezoelectric substrate,~~;~~ and first to third IDTs arranged in a surface acoustic wave propagating direction on the piezoelectric substrate, wherein ~~the balanced-type surface acoustic wave filter being characterized in that~~ the first and third IDTs located on both ~~the~~ sides of the second IDT in the surface acoustic wave propagating direction are connected to the unbalanced terminal, the second IDT includes first and second IDT sections divided in the surface acoustic wave propagating direction and the first and second IDT sections are respectively electrically connected to the first and second balanced signal terminals, the first to third IDTs are arranged such that ~~constructed to set~~ a phase of a signal emanating from the unbalanced terminal to the first balanced signal terminal reversed by about 180 degrees with respect to a phase of a signal emanating from the unbalanced terminal to the second balanced signal terminal, and in an area

where the first to third IDTs are adjacent one another in the surface acoustic wave propagating direction with a gap interposed therebetween, the respective IDTs have narrow pitch electrode finger sections at areas near the gap, and when an electrode finger pitch of the narrow pitch electrode finger section of the first and third IDTs connected to the unbalanced signal terminal is set as P1, the number of electrode fingers of the narrow pitch electrode finger section thereof is set as N1, an electrode finger pitch of the narrow pitch electrode finger section of the second IDT whose first and second IDT sections are respectively connected to the first and second balanced signal terminal is set as P2, and the number of electrode fingers of the narrow pitch electrode finger section thereof is set as N2, the following relationships:

$P1 \neq P2$; and

$N1 < N2$

are satisfied.

[0026] In the seventh to ninth preferred embodiments~~inventions~~, preferably, $P1 < P2$ is satisfied.

[0027] The balanced-type surface acoustic wave filters according to the first and second preferred embodiments are~~inventions is~~ provided with the first and second surface acoustic wave filter sections in which the second IDT in the center or the first and third IDTs on both ~~the~~ sides of the second IDT are connected to the unbalanced terminal, the first and third IDTs or the second IDT of the first surface acoustic

wave filter section are ~~is~~ connected to the first balanced terminal and the first and third IDTs or the second IDT of the second surface acoustic wave filter section are ~~is~~ connected to the balanced terminal, and the phases of the output signals of the first and second surface acoustic wave filter sections are ~~constructed to be~~ different by about 180 degrees. Therefore, the balanced-type surface acoustic wave filter provided with the balance-unbalance conversion function is provided~~constructed~~.

[0028] Then, in the first and second surface acoustic wave filter sections, the pair of IDTs adjacent to each other with a gap interposed therebetween has a narrow pitch electrode finger section where a cycle of a portion~~part~~ of electrode fingers including an electrode finger facing the gap is less~~smaller~~ than a cycle of electrode fingers of a main portion~~part~~ of the IDT. Then, as P1>P2 and 1.12≤K1/K2≤1.65 are satisfied, it is possible to obtain the surface acoustic wave filter in which the insertion loss and the VSWR in the pass band are small, and not only the filter characteristic having the sufficient band width can be obtained but also the impedance ratio between the unbalanced signal terminal and the balanced signal terminal can be set to 1:2 with certainty.

[0029] In particular, as it is possible to change the impedance ratio not only by adjusting the number of electrode fingers of the IDT but also by adjusting the pitch ratio of the narrow pitch electrode finger section, the impedance ratio between the unbalanced signal terminal and the balanced signal

terminal can be precisely set to 1:2~~ with precision~~.

[0030] In particular, according to the second preferred embodiment~~invention~~, as $K1n=K2n$ is satisfied, the setting of the narrow pitch electrode finger section is facilitated, and at the same time the effect of suppressing the discontinuity in the area where the IDTs are located adjacent is ~~can be~~ further enhanced.

[0031] In the first and second preferred embodiments~~inventions~~, when $67.4\ \lambda I \le W/d \le 74.3\ \lambda I$ is satisfied, ~~it is possible to set~~ the impedance of the unbalanced terminal can be precisely set to 50 Ω and the impedance of the balanced terminal can be precisely set to 100 Ω~~Ω with precision~~, and the balanced-type surface acoustic wave filter connected to the IC of the input impedance of 100 Ω is ~~can be~~ easily provided.

[0032] In the balanced-type surface acoustic wave filters according to the third and fourth preferred embodiments~~inventions~~, as the second IDT is connected to the unbalanced terminal, the first and third IDTs on both ~~the~~ sides of the second IDT are connected to the first and second balanced terminal, and the phase of the first IDT is reversed by about 180 degrees with respect to the phase of the third IDT, similarly to the first preferred embodiment~~invention~~, the balanced-type surface acoustic wave filter provided with the balance-unbalance conversion function is provided.~~constructed.~~ Then, the first to third IDTs include~~have~~ the narrow pitch electrode finger sections, and $P1>P2$ and $1.12 \le K1/K2 \le 1.65$ are satisfied. Therefore, a~~, and therefore it is possible to obtain the~~ surface acoustic wave filter is

obtained in which ~~for making it possible that~~ the insertion loss and the VSWR in the pass band are greatly reduced~~small~~, and not only the filter characteristic having the sufficient band width is~~can be~~ obtained, but also the impedance ratio between the unbalanced signal terminal and the balanced signal terminal is reliably set to about 1:2~~ with reliability~~. In particular, as ~~it is possible to change~~ the impedance ratio can be changed not only by adjusting the number of electrode fingers of the IDT, but also by adjusting the pitch ratio of the narrow pitch electrode finger section, the impedance ratio between the unbalanced signal terminal and the balanced signal terminal is precisely set to 1:2 ~~with precision~~.

[0033] ——In particular, according to the fourth preferred embodiment~~invention~~, K1n=K2n is satisfied, and therefore, the designing of the IDT having the narrow pitch electrode finger section is facilitated, and at the same time the effect of suppressing the discontinuity of the area where the IDTs are adjacent due to the provision of the narrow pitch electrode finger section is ~~can be~~ enhanced.

[0034] ——In the third and fourth preferred embodiments~~inventions~~, when 134.8 $\lambda I \leq W/d \leq 148.6\ \lambda I$ is satisfied, ~~it is possible to set~~ the impedance of the unbalanced terminal of ~~to~~ 50 Ω and the impedance of the balanced terminal of ~~to~~ 100 Ω can be precisely set~~with precision~~, making it possible to easily provide the balanced-type surface acoustic wave filter connected to the IC of the input impedance of about 100 Ω.

[0035] According to the fifth and sixth preferred embodiments~~inventions~~, as the first to third IDTs are arranged in the surface acoustic wave propagating direction on the piezoelectric substrate, the first and third IDTs are connected to the unbalanced terminal, the second IDT includes the first and second IDT sections divided in the surface acoustic wave propagating direction, the first and second IDT sections are respectively connected to the first and second balanced signal terminals, and the phase of the signal from the unbalanced terminal to the first balanced terminal is reversed by about 180 degrees with respect to the phase of the signal from the unbalanced terminal to the second balanced terminal, similar~~similarly~~ to the first and second preferred embodiment~~inventions~~, the balanced-type surface acoustic wave filter provided with the balance-unbalance conversion function is provided~~constructed~~.

[0036] Then, in the third preferred embodiment~~invention as well~~, the first to third ~~the first and third~~ IDTs have the narrow pitch electrode finger section in which~~,~~ P1>P2 and 1.12≤K1/K2≤1.65 are satisfied. Therefore, the insertion loss and the VSWR in the pass band of ~~, and therefore it is possible to obtain~~ the surface acoustic wave filter ~~for making it possible that the insertion loss and the VSWR in the pass band~~ are small. In addition,~~, and~~ not only are ~~the~~ sufficient filter characteristics and ~~characteristic having the~~ sufficient band width ~~can be~~ obtained, but also the impedance ratio between the

unbalanced signal terminal and the balanced signal terminal is set to 1:2. In particular, as ~~it is possible to change~~ the impedance ratio can be changed not only by adjusting the number of electrode fingers of the IDT, but also by adjusting the pitch ratio of the narrow pitch electrode finger section, the impedance ratio between the unbalanced signal terminal and the balanced signal terminal can be precisely set to 1:2~~ with precision~~.

[0037] In particular, according to the sixth preferred embodiment~~invention~~, K1n=K2n is satisfied, and therefore, the designing of the IDT having the narrow pitch electrode finger section is facilitated, and at the same time the effect of the provision of the narrow pitch electrode finger section N, namely, the effect of suppressing the discontinuity of the area where the IDTs are adjacent is ~~can be~~ further enhanced.

[0038] In the fifth and sixth preferred embodiments~~inventions~~, when 134.8 $\lambda I \leq W/d \leq 148.6\ \lambda I$ is satisfied ~~it is possible to set~~ the impedance of the unbalanced terminal can be precisely set to 50 Ω the impedance of the balanced terminal can be precisely set to 100 **Ω**~~Ω with precision~~, and the balanced-type surface acoustic wave filter connected to the IC of the input impedance of 100 Ω is~~can be provided~~ easily provided.

[0039] According to the seventh preferred embodiment~~invention~~, the first and second surface acoustic wave filter sections including the first to third IDTs on the piezoelectric substrate are provided, the second IDT in the center or the first and third IDTs on both ~~the~~ sides of the

second IDT of the first and second surface acoustic wave filter sections are connected to the unbalanced signal terminal and the first and third IDTs on both sides of the second IDT or the second IDT of the first surface acoustic wave filter section is connected to the first balanced signal terminal, the first and third IDTs on both sides of the second IDT or the second IDT of the second surface acoustic wave filter section is connected to the second balanced signal terminal, and the pair of IDTs~~ITDs~~ adjacent in the surface acoustic wave propagating direction have a narrow pitch electrode finger section where a cycle of a portion~~part~~ of electrode fingers including an electrode finger facing the gap is less~~smaller~~ than a cycle of electrode fingers of a main portion~~part~~ of the IDT. In the balanced-type surface acoustic wave filter provided with the balance-unbalance conversion function, P1≠P2 and N1<N2 are satisfied, and therefore, it is possible to increase the degree of freedom for adjusting impedances of the respective resonant modes. Therefore, the impedance ratio between the unbalanced signal terminal and the balanced signal terminal can be easily set to 1:2 ~~easily~~ without degrading the film characteristic.

[0040] Thus, a ~~it is possible to obtain the~~ surface acoustic wave filter in which~~for making it possible that~~ the insertion loss and the VSWR in the pass band are small, and not only ~~the~~ sufficient filter characteristics having a ~~the~~ sufficient band width are ~~can be~~ obtained, but also, the impedance ratio between the unbalanced signal terminal and the

balanced signal terminal can be precisely set to 1:2.

[0041] In particular, ~~it is possible to change~~ the impedance ratio can be changed not only by adjusting the number of electrode fingers of the IDT but also by adjusting the pitch ratio of the narrow pitch electrode finger section, and the impedance ratio between the unbalanced signal terminal and the balanced signal terminal can be precisely set to 1:2.

[0042] According to the eighth preferred embodiment~~invention~~, in the balanced-type surface acoustic wave filter provided with the balance-unbalance conversion function in which the first to third IDTs are arranged on the piezoelectric substrate, the second IDT is connected to the unbalanced signal terminal, the first and third IDTs on both ~~the~~ sides of the second IDT are connected to the first and second balanced signal terminals, and the first to third IDTs have the narrow pitch electrode finger section in which~~,~~ P1≠P2 and N1<N2 are satisfied, and therefore it is possible to obtain the surface acoustic wave filter in which~~for making it possible that~~ the insertion loss and the VSWR in the pass band are small. In addition, ~~and~~ not only are the sufficient filter characteristics having the sufficient band width ~~can be~~ obtained, but also, the insertion loss and the VSWR in the pass band are small.

[0043] In particular, ~~it is possible to change~~ the impedance ratio can be changed not only by adjusting the number of electrode fingers of the IDT, but also, by adjusting the pitch ratio of the narrow pitch electrode finger section, and the ~~he~~

impedance ratio between the unbalanced signal terminal and the balanced signal terminal can be set to 1:2.

[0044] According to the ninth preferred embodiment~~invention~~, in the balanced-type surface acoustic wave filter provided with the balance-unbalance conversion function in which the first to third IDTs are arranged in the surface acoustic wave propagating direction on the piezoelectric substrate, the first and third IDTs are connected to the unbalanced signal terminal, the second IDT is divided into the first and second IDT sections, the first and second IDT sections are respectively connected to the first and second balanced signal terminals, and the first to third IDTs have the narrow pitch electrode finger section, in which $P1 \neq P2$ and $N1 < N2$ are satisfied. Therefore, a ~~, and therefore it is possible to obtain the~~ surface acoustic wave filter in which~~for making it possible that~~ the insertion loss and the VSWR in the pass band are small is obtained. In addition,~~and~~ not only can the sufficient filter characteristics having the sufficient band width ~~can~~ be obtained, but also, the impedance ratio between the unbalanced signal terminal and the balanced signal terminal can be precisely set to 1:2.

[0045] In particular, ~~as it is possible to change~~ the impedance ratio can be changed not only by adjusting the number of electrode fingers of the IDT, but also, by adjusting the pitch ratio of the narrow pitch electrode finger section. Thus, the impedance ratio between the unbalanced signal terminal and the

balanced signal terminal can be precisely set to 1:2~~ with precision~~.

[0046] In the seventh to ninth preferred embodiments~~inventions~~, preferably, P1<P2 is satisfied, and in that case, the VSWR in the pass band can be further reduced, whereby it is possible to obtain even more satisfactory filter characteristics.

[0047] Other features, elements, steps, characteristics and advantages of the present invention will become more apparent from the following detailed description of preferred embodiments of the present invention with reference to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0048] Fig. 1 is a schematic plan diagram showing an electrode construction of a balanced-type surface acoustic wave filter according to a first preferred embodiment of the present invention.

[0049] Fig. 2 is a graph showing an attenuation-frequency characteristic of the surface acoustic wave filter according to the first preferred embodiment of the present invention.

[0050] Fig. 3 is a graph showing a VSWR characteristic of the surface acoustic wave filter according to the first preferred embodiment of the present invention.

[0051] Figs. 4A~~(a)~~ and 4B~~(b)~~ are Smith charts showing reflection characteristics of S1 and S2 of the surface acoustic wave filter according to the first preferred embodiment of the

present invention.

[0052] Fig. 5 is a graph showing an attenuation-frequency characteristic of a narrow pitch electrode finger section of the surface acoustic wave filter in which electrode finger pitches are set equal to each other prepared for comparison.

[0053] Fig. 6 is a graph showing a VSWR-frequency characteristic of the surface acoustic wave filter in which electrode finger pitches are set equal to each other prepared for comparison.

[0054] Figs. 7A~~(a)~~ and 7B~~(b)~~ are Smith charts showing reflection characteristics of S11 and S22 of the surface acoustic wave filter in which electrode finger pitches are set equal to each other prepared for comparison.

[0055] Figs. 8A~~(a)~~ and 8B~~(b)~~ are Smith charts showing reflection characteristics of S11 and S22 of the surface acoustic wave filter designed to set the impedance of the unbalanced signal terminal to 50 Ω and set the impedance of the balanced signal terminal to 150 Ω.

[0056] Figs. 9A~~(a)~~ and 9B~~(b)~~ are Smith charts showing reflection characteristics of S11 and S22 obtained when the impedance of the unbalanced signal terminal is set to 50 Ω and the impedance of the balanced signal terminal is set to 100 Ω.

[0057] Figs. 10A~~(a)~~ and 10B~~(b)~~ are Smith charts showing reflection characteristics on the S11 side and the S22 side obtained when the electrode finger cross width of the surface acoustic wave filter is changed to 51.0 λI.

[0058] Figs. 11A~~(a)~~ and 11B~~(b)~~ are Smith charts showing reflection characteristics on the S11 side and the S22 side obtained when the electrode fingers of the IDT are changed to set the impedance on the S11 side high and set the impedance of the S22 side low.

[0059] Figs. 12A~~(a)~~ and 12B~~(b)~~ are Smith charts showing reflection characteristics on the S11 side and the S22 side obtained when the electrode finger pitch of the narrow pitch electrode finger section of the IDT is changed from 0.444 λI to 0.438 λI.

[0060] Figs. 13A~~(a)~~ and 13B~~(b)~~ are Smith charts showing reflection characteristics on the S11 side and the S22 side obtained when the electrode finger pitch of the narrow pitch electrode finger section of the second IDT in the center is changed from 0.444 λI to 0.454 λI.

[0061] Fig. 14 is a graph for describing three resonant modes appearing in the balanced-type surface acoustic wave filter.

[0062] Figs. 15A and 15B are diagrams for describing an effective current distribution of each of the resonant modes shown in Fig. 14, in which Fig. 15A~~(a)~~ is a schematic construction diagram of the IDT and Fig. 15B~~(b)~~ is a graph showing each of the resonant modes corresponding to a position of the IDT.

[0063] Fig. 16 is a graph showing changes in the VSWR when the electrode finger cross width and the number of electrode fingers of the electrode finger section of the IDT are changed.

[0064] Fig. 17 is a graph showing an attenuation-frequency characteristic of the surface acoustic wave filter according to a second preferred embodiment of the present invention.

[0065] Fig. 18 is a graph showing the VSWR characteristic of the surface acoustic wave filter according to the second preferred embodiment of the present invention.

[0066] Figs. 19A~~(a)~~ and 19B~~(b)~~ are Smith charts showing reflection characteristics on the S11 side and the S22 side in the surface acoustic wave filter according to the second preferred embodiment of the present invention.

[0067] Figs. 20A~~(a)~~ and 20B~~(b)~~ are Smith charts showing reflection characteristics on the S11 side and the S22 side obtained when the number of electrode fingers connected to the balanced signal terminal of the narrow pitch electrode finger section in the surface acoustic wave filter according to the second preferred embodiment is changed from three to five.

[0068] Fig. 21 is a schematic diagram showing a surface acoustic wave filter according to a third preferred embodiment of the present invention.

[0069] Fig. 22 is a schematic diagram showing a surface acoustic wave filter according to a fourth preferred embodiment of the present invention.

[0070] Fig. 23 is a schematic diagram showing a surface acoustic wave filter according to a fifth preferred embodiment of the present invention.

[0071] Fig. 24 is a schematic diagram showing a surface acoustic wave filter according to a sixth preferred embodiment of the present invention.

[0072] Fig. 25 is a schematic diagram showing a surface acoustic wave filter according to a seventh preferred embodiment of the present invention.

[0073] Fig. 26 is a schematic diagram showing an example of a related-art balanced-type surface acoustic wave filter.

[0074] Fig. 27 is a schematic diagram showing another example of the related-art the balanced-type surface acoustic wave filter.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

~~Reference Numerals~~

~~1 balanced-type surface acoustic wave filter~~

~~2 piezoelectric substrate~~

~~3 unbalanced input terminal~~

~~4 first longitudinal coupled resonator type surface acoustic wave filter section~~

~~4a to 4c first to third IDTs~~

~~4d and 4e reflector~~

~~5 second longitudinal coupled resonator type surface acoustic wave filter section~~

~~5a to 5c the first to third IDTs~~

~~5d, 5e reflector~~

~~6 1-port type surface acoustic wave resonator~~

~~7 first balanced output terminal~~

~~8 1-port type surface acoustic wave resonator~~

~~9 second balanced output terminals~~

~~21 balanced-type surface acoustic wave filter~~

~~22 piezoelectric substrate~~

~~23 unbalanced input terminal~~

~~24a to 24e IDT~~

~~24f, 24g reflector~~

~~25, 26 the first and second balanced signal terminals~~

~~31 balanced-type surface acoustic wave filter~~

~~32 piezoelectric substrate~~

~~33 unbalanced input terminal~~

~~34, 35 surface acoustic wave filter section~~

~~34a to 34e IDT~~

~~34c1, 34c2 IDT division section~~

~~34f, 34g reflector~~

~~37 and 39 balanced output terminal~~

~~41 surface acoustic wave filter~~

~~42a to 42e IDT~~

~~43 unbalanced input terminal~~

~~47 and 49 balanced output terminal~~

~~50, 51 surface acoustic wave filter~~

~~52a to 52e IDT~~

~~52f and 52g reflector~~

~~53 unbalanced input terminal~~

~~57, 59 balanced output terminal~~

~~70 surface acoustic wave filter section~~

~~N narrow pitch electrode finger section~~

~~Best Mode for Carrying Out the Invention~~

[0075] Hereinafter, with reference to the drawings, the present invention will be made apparent by describing specific preferred embodiments of the present invention.

[0076] Fig. 1 is a schematic plan diagram showing an electrode construction of a balanced-type surface acoustic wave filter according to a first preferred embodiment of the present invention.

[0077] In a balanced-type surface acoustic wave filter 1, an electrode construction as shown is provided ~~formed~~ on a piezoelectric substrate 2.

[0078] In the balanced-type surface acoustic wave filter 1, first and second longitudinally coupled resonator type surface acoustic wave filter sections 4 and 5 are connected to an unbalanced input terminal 3.

[0079] The first longitudinally coupled resonator type surface acoustic wave filter section 4 includes three IDTs 4a to 4c which are arranged along the surface acoustic wave propagating direction and reflectors 4d and 4e which are arranged on both ~~the~~ sides in~~of~~ the surface acoustic wave propagating direction of~~in~~ the area where the IDTs 4a to 4c are arranged. The first to third IDTs 4a to 4c include narrow pitch electrode finger sections N. That is, by taking the IDTs 4a and 4b as an example, the IDTs 4a and 4b are adjacent to each other with a gap

interposed therebetween. The pitch of a plurality of electrode fingers including electrode fingers facing the gap in the IDTs 4a and 4b is narrower than ~~are made narrow as compared with~~ an electrode finger pitch of the remaining main portion~~part~~ electrode finger section of the IDTs 4a and 4b. An electrode finger section with this relatively small electrode finger pitch is a narrow pitch electrode finger section N.

[0080] Similarly, in ~~In~~ an area where the IDTs 4b and 4c are adjacent to each other~~ as well~~, the IDTs 4b and 4c include~~includes~~ the narrow pitch electrode finger sections N. With the ~~provision of the~~ narrow pitch electrode finger sections N, the discontinuity of the area where a pair of the IDTs are adjacent to each other with a gap interposed therebetween and the gap between the IDTs are adjusted, making it possible to obtain a band pass filter with a wider band width. The effect of ~~the provision of~~ such a narrow pitch electrode finger section is ~~already~~ known as described in, for example, Patent Document 4 described above.

[0081] The longitudinally coupled resonator type surface acoustic wave filter section 5 also includes the first to third IDTs 5a to 5c and the reflectors 5d and 5e. The~~ similarly. Then, the~~ IDT 5a to 5c also include~~includes~~ the narrow pitch electrode finger sections N.

[0082] The second IDT 4b and 5b located in the center of the surface acoustic wave filter sections 4 and 5 are electrically connected to the unbalanced input terminal 3. The

other ends of the IDTs 4b and 5b are connected to a ground~~an earth~~ potential.

[0083] In the surface acoustic wave filter section 4, the first and third IDTs 4a and 4c located on both ~~the~~ sides of the second IDT 4b are electrically connected to a first balanced output terminal 7 via a 1-port type surface acoustic wave resonator 6.

[0084] In the same manner, in the surface acoustic wave filter section 5, the second IDT in the center 5b is connected to the unbalanced input terminal 3. The first and third IDTs 5a and 5c located on both ~~the~~ sides of the IDT 5b are electrically connected to a second balanced output terminals 9 via a 1-port type surface acoustic wave resonator 8. The first longitudinally coupled resonator type surface acoustic wave filter section 4 and the second longitudinally coupled resonator type surface acoustic wave filter section 5 have ~~all~~ the same configuration~~constructions~~ except that the phase of the output signal is different by about 180 degrees from~~with respect to~~ the input signal.

[0085] As described above, the IDTs 5a and 5c are reversed~~reverted~~ in phase by about 180 degrees with respect to the IDTs 4a and 4c of the first surface acoustic wave filter section 4. Therefore, the signal emanating from the first balanced output terminal 7 and the signal emanating from the second balanced output terminal 9 are reversed in phase by about 180 degrees. Thus, according to this preferred embodiment, the

balanced-type surface acoustic wave filter 1 including the unbalanced input terminal 3 and the first and second balanced output terminals 7 and 9 is provided~~constructed~~.

[0086] ~~—~~The 1-port type surface acoustic wave resonators 6 and 8 ~~are constructed to~~ have the same electrode configuration~~construction~~.

[0087] ~~—~~The reason for the connection of the 1-port type surface acoustic wave resonator 6 is that the attenuation in the neighborhood of the pass band can be increased~~enlarged~~ and the steepness of the filter characteristic can be increased. Then, with the connection of the 1-port type surface acoustic wave resonators 6 and 8, it is possible to adjust the impedances of a plurality of resonant modes in the pass band described below. However~~In the meantime however~~, the surface acoustic wave resonators 6 and 8 may not be provided~~used~~.

[0088] ~~—~~It should be noted that the 1-port type surface acoustic wave resonators 6 and 8 may be configured so as not to include~~have a construction including no~~ reflectors.

[0089] ~~—~~The electrode finger pitch of the narrow pitch electrode finger section N of the second IDT 4b and 5b in the first and second surface acoustic wave filter sections 4 and 5 is ~~set to~~ P1, and the electrode finger pitch of the narrow pitch electrode finger section N of the first and third IDTs 4a, 4c, 5a, and 5c is ~~set to~~ P2. Then, the number of electrode fingers of the electrode finger section except for the narrow pitch electrode finger section of the respective second IDTs 4b and 5b

is ~~set as~~ K1 and the number of electrode fingers of the electrode finger section except for the narrow pitch electrode finger section of the first and third IDTs is ~~set as~~ K2.

[0090] Furthermore, the ~~second IDT 4b and 5b of the~~ number of electrode fingers of the narrow pitch electrode finger section of the first and second surface acoustic wave sections 4 and 5 is ~~set as~~ K1n, and the number of electrode fingers of the narrow pitch electrode finger section of the first and third IDTs 4a, 4c, 5a, and 5c is ~~set as~~ K2n.

[0091] In this preferred ~~The feature of this~~ embodiment ~~resides in the setting of~~ P1>P2, K1n=K2n~~,~~ and 1.12≤K1/K2≤1.65. Accordingly, ~~not much influence is imparted on~~ the filter characteristic are not substantially influenced, and it is possible to easily change the impedance ratio of the unbalanced input terminal 3 and the balanced output terminals 7 and 9. In particular, the impedance ratio can be changed not only by adjusting the number of electrode fingers of the IDT, but also, by adjusting the pitch ratio of the narrow pitch electrode finger section N~~, the impedance ratio can be changed~~. Thus, the impedance ratio between the unbalanced signal terminal and the balanced signal terminal can be precisely set, for example, to 1:2~~ with precision~~.

[0092] In particular, when~~while~~ the metallization ratio between the first and second surface acoustic wave sections 4 and 5 is set as d and an electrode finger cross width is set as W, ~~in the case~~ where 67.4 λI≤W/d≤74.3 λI (where λI denotes a wavelength

of the IDT) is satisfied, it is easy to set the impedance on the unbalanced input terminal 3 side to about 50 Ω and the impedance on sides of the balanced output terminals 7 and 9 sides to about 100 Ω.~~Ω with requirement.~~ This will be described in more detail with reference to specific examples.

[0093] ~~—~~It should be noted that, to simplify~~ regarding the electrode construction of~~ the drawings~~ attached to this specification, for simplifying the graphic representation~~, the number of electrode fingers of the IDTs and the reflectors shown in the figures is less than the ~~are represented with the smaller amount as compared with the number of~~ actual ~~number of~~ electrode fingers.

[0094] ~~—~~The surface acoustic wave filter 1 is manufactured~~fabricated~~ by the following method~~specification~~.

[0095] ~~—~~An electrode finger cross width of the longitudinally coupled resonator type surface acoustic wave filter section is set to about 51.0 λI. λ denotes an electrode finger pitch except for the narrow pitch electrode finger section of the IDT. In the IDTs 4a to 4c, the electrode finger cross widths are set to be equal to each other.

[0096] ~~—~~The number of electrode fingers of the IDT 4a is set to 22 (3), the number of electrode fingers of the IDT 4b is set to (3) 31 (3), and the number of electrode fingers of the IDT 4c is set to (3) 22. It should be noted that the number of electrode fingers in parentheses~~brackets~~ represents the number of electrode fingers of one narrow pitch electrode finger section N

and the number of electrode fingers outside the parentheses~~brackets~~ represents the number of electrode fingers except for the narrow pitch electrode finger section N.

[0097] The number of the electrode fingers of the respective reflectors 4d and 4e: 85.

[0098] The metallization ratio in the IDTs 4a to 4c and the reflectors 4d and 4e: about 0.72 except for the narrow pitch electrode finger section and about 0.68 in the narrow pitch electrode finger section N.

[0099] The electrode film thickness=0.092 λI.

It should be noted that the surface acoustic wave filter section 5 is designed in the same manner as described above, except that directions of the IDTs 5a and 5c are reversed with respect to those of the IDTs 4a and 4c.

[0100] Specification of the 1-port type surface acoustic wave resonator 6.

[0101] The electrode finger cross width: 23.8 λI (where λI denotes a wavelength defined by the electrode finger pitch of the IDT 6a).

[0102] The number of electrode fingers of the IDT: 161.

[0103] The number of electrode fingers of the respective reflectors 6a and 6c: 15.

[0104] The metallization ratio: 0.60.

[0105] The electrode film thickness: 0.095 λI.

[0106] It should be noted that a 40 ± 5 degree Y-cut X-propagating $LiTaO_3$ substrate is preferably used as the

piezoelectric substrate 2 and the above-mentioned respective electrodes are preferably formed of Al. In this manner, a DCS reception filter is obtained in which~~with~~ the unbalanced input terminal 3 having the input impedance of about 50 Ω and the balanced output terminals 7 and 9 having the impedance of about 100 Ω.

[0107] Characteristics of the surface acoustic wave filter 1 designed as described above are shown in Figs. 2 to 4. Fig. 2 shows an attenuation frequency characteristic of the surface acoustic wave filter 1. Then, Fig. 3 shows a VSWR characteristic of the surface acoustic wave filter 1. Fig. 4A~~4 (a)~~ and 4B~~(b)~~ are Smith charts showing a reflection characteristic of S11 on the unbalanced signal terminal and a reflection characteristic of S22 on the balanced signal terminal. It should be noted that in the drawings attached to this specification, hereinafter, the reflection characteristic on the unbalanced signal terminal of the surface acoustic wave filter is ~~set as~~ S11 and the reflection characteristic on the balanced signal terminal is ~~set as~~ S22.

[0108] One feature of this preferred embodiment is ~~resides in~~ that an electrode finger pitch P1 of the narrow pitch electrode finger section N of the IDTs 4b and 5b connected to the unbalanced input terminal 3 and an electrode finger pitch P2 of the narrow pitch electrode finger section N of the IDTs 4a, 4c, 5a, and 5c connected to and the balanced output terminals 7 and 9 are different from each other. That is, when a wavelength

defined by the electrode finger pitch of the main portion~~part~~ of the electrode finger section except for the narrow pitch electrode finger section N of the IDTs 4a to 4c and 5a to 5c is ~~set as~~ λI, the electrode finger pitch P1 of the narrow pitch electrode finger section N of the second IDT 4b and 5b is about ~~set to~~ 0.454 λI and the pitch P2 of the narrow pitch electrode finger section of the first and third IDTs 4a, 4c, 5a, and 5c is about ~~set to~~ 0.438 λI. Therefore, the electrode finger pitch P1 of the narrow pitch electrode finger section N in the IDTs 4b and 5b connected to the unbalanced input terminal 3 is set to be greater~~larger~~ than the electrode finger pitch of the narrow pitch electrode finger section P2 in the IDTs 4a, 4c, 5a, and 5c connected to the balanced output terminals 7 and 9.

[0109] Figs. 5 to 7 show the~~a~~ filter characteristic of a balanced-type surface acoustic wave filter that is constructed similarly to the balanced-type surface acoustic wave filter 1 of the above-mentioned preferred embodiment, except that the electrode finger pitches of all of the narrow pitch electrode finger sections N are set ~~equal~~ to about 0.447 λI for comparison. Fig. 5 shows an attenuation frequency characteristic of the above-described ~~mentioned~~ surface acoustic wave filter prepared for comparison and Fig. 6 shows a VSWR characteristic. Figs. 7A~~(a)~~ and 7B~~(b)~~ show reflection characteristics S11 and S22, respectively.

[0110] It should be noted that the pass band for the DCS reception filter is 1805 MHz to 1880 MHz. As is apparent from

the comparison of Figs. 2 and 3 with Figs. 5 and 6, in the surface acoustic wave filter prepared for comparison, the above-mentioned maximum insertion loss in the pass band is about 2.16 dB and the maximum value of the VSWR is about 2.00, whereas in the surface acoustic wave filter 1 according to the above-mentioned preferred embodiment, ~~it is understood that~~ the maximum insertion loss in the pass band is reduced to about 2.13 dB and the maximum value of the VSWR in the pass band is also reduced to about 1.83. Therefore, according to this preferred embodiment, ~~it is understood that~~ the maximum insertion loss in the pass band is ~~can be~~ improved by ~~to~~ about 0.15 dB and ~~also~~ the VSWR is ~~can be~~ improved by about 0.20.

[0111] In this preferred embodiment, the reason why the insertion loss and the VSWR in the pass band is ~~can be~~ improved ~~in the above-mentioned manner~~ will be described with reference to Figs. 8A to 13B.

[0112] ~~.~~ First of all, Figs. 8A ~~(a)~~ and 8B ~~(b)~~ show the reflection characteristics S11 and S22 obtained when the surface acoustic wave filter is designed such ~~so~~ that the impedance of the unbalanced input terminal 3 is set to about 50 Ω and the balanced output terminals 7 and 9 is set to about 150 Ω in the electrode configuration~~construction~~ shown in Fig. 1. Design parameters ~~at this time~~ are as follows.

[0113] The electrode finger cross width of the surface acoustic wave filter=41.7 λI.

[0114] The number of electrode fingers of the IDT 4a: 20

(3), the number of electrode fingers of the IDT 4b: (3) 33 (3), and the number of electrode fingers of the IDT 4c corresponds to (3) 20.

[0115] The number of electrode fingers of the reflectors: 85.

[0116] The metallization ratio: 0.72 (the metallization ratio of the narrow pitch electrode finger section is set to 0.68).

[0117] The electrode film thickness: 0.092 λI.

[0118] The electrode finger pitch of the narrow pitch electrode finger section N: 0.444 λI.

[0119] Figs. 9A~~(a)~~ and 9B~~(b)~~ show the reflection characteristics S11 and S22 obtained when ~~reflection characteristics of the surface acoustic wave filter designed as described above are regarded in which~~ the impedance of the unbalanced input terminal is set to about 50 Ω and the impedance of the balanced output terminals is set to about 100 Ω. As is apparent from Figs. 9A and 9B, the impedance of the S22 side is substantially~~largely~~ shifted from 100 Ω, which is the matching point.

[0120] Next, Figs. 10A~~(a)~~ and 10B~~(b)~~ show characteristics obtained when ~~to set the impedance of the S22 side to 100 Ω,~~ the electrode finger cross width of the first and second longitudinally coupled resonator type surface acoustic wave filter sections 4 and 5 is changed from about 41.7 λI to about 751.0 λI. At this time, the impedance of the S22 side is about

100 Ω. However, the impedance on the S11 side is substantially~~largely~~ shifted from 50 Ω, which is the matching point.

[0121] Next, in order for~~that~~ the impedance on the S11 side to be ~~is~~ high and at the same time the impedance of the S22 side to be ~~is~~ low, the number of electrode fingers the IDTs 4b and 5b is set to a low number and the number of electrode fingers of the IDTs 4a, 4c, 5a, and 5c is set to a large number. That is, the construction is changed from 20 (3)/(3) 33 (3)/(3) 20 to 22 (3)/(3) 31 (3)/(3) 22. Figs. 11A~~(a)~~ and 11B~~(b)~~ show the reflection characteristics of the surface acoustic wave filter that is~~thus~~ changed as described above. As is apparent from Figs. 11A and 11B~~. 11~~, in this case, among three resonances A to C defining~~forming~~ the pass band of the longitudinally coupled resonator type surface acoustic wave filter section, the impedance of the resonance A is high on the S11 side as desired and low on the S22 side. However, it is understood that the impedances of the resonances B and C are not substantially changed~~hardly change~~.

[0122] It should be noted that the above-mentioned resonances A to C refer to three resonances A to C defining~~constructing~~ the pass band of the longitudinally coupled resonator type surface acoustic wave filter section as shown in Figs. 14 and 15. Here, the resonance A, the resonance B, and the resonance c appear in the ascending order of the frequencies, and as is apparent from Fig. 15, the resonance A is the 2nd mode

resonance and the resonance B is the 0th mode resonance.

[0123] Next, ~~from the constructions for obtaining the reflection characteristics S11 and S22 shown in Figs. 11(a) and 11(b) and~~ Figs. 11A and 11B and Figs. 12A and 12B~~12(a) and 12(b)~~ show characteristics obtained when the electrode finger pitch of the narrow pitch electrode finger section N of the IDTs 4a and 4c, and 5a and 5c is changed to about 0.438 λI. That is, the electrode finger pitch of the narrow pitch electrode finger section is changed from about 0.444 λI to about 0.438 λI. As a result, as is apparent from Fig. 12A, ~~(a), it is understood that~~ a concentration ratio of the resonances A to C on the S11 side, that is, a concentration ratio of the impedance is improved. However, at the same time, ~~it is understood that~~ the impedance of the resonance B on the S11 side is too capacitive,~~capacitative~~ and furthermore,~~ that of~~ the resonance C on the S22 side is too inductive.

[0124] Next, ~~from the constructions for obtaining the characteristics shown in Fig. 11,~~ Figs. 13A~~(a)~~ and 13B~~(b)~~ show characteristics obtained when the electrode finger pitch of the narrow pitch electrode finger section N of the IDTs 4b and 5b is changed to about 0.454 λI. That is, Figs. 13A~~(a)~~ and 13B~~(b)~~ show characteristics obtained when the electrode finger pitch of the narrow pitch electrode finger section N is changed from about 0.444 λI to about 0.454 λI. In this case, in contract to ~~the case~~ where the electrode finger pitch of the narrow pitch electrode finger section P2 of the IDTs 4a and 4c, and 5a and 5c

is set small, although the concentration ratio of the impedance on the S11 side is degraded, ~~such a change occurs that~~ the impedance of the resonance B on the S11 side is inductive and that of the resonance C on the S22 side is capacitive. That~~capacitative, that is, it~~ is, ~~understood that~~ when the electrode finger pitch P2 of the narrow pitch electrode finger section N of the IDTs 4a, 4c, 5a, and 5c connected to the balanced output terminals 7 and 9 is set to be small, by increasing the ~~setting the large~~ electrode finger pitch P1 of the narrow pitch electrode finger section N of the IDTs 4b and 5b, the respective detriments are compensated for.~~demerits are covered up.~~ Therefore, with this~~the provision of such a~~ construction, in the balanced-type surface acoustic wave filter according to the first preferred embodiment described above, as shown in Figs. 4A~~(a)~~ and 4B,~~(b), it is understood that while~~ the impedance ratio between the impedance of the balanced input terminal 3 and the balanced output terminals 7 and 9 is adjusted, the degradation in the filter characteristic is effectively ~~can be~~ suppressed.

[0125] ~~—~~Next, in the surface acoustic wave filter 1 configured~~constructed~~ to satisfy P1>P2, when the impedance ratio between the unbalanced input terminal 3 and the balanced output terminals 7 and 9 is set to about 1:2, the number~~log~~ and the cross width of the electrode fingers of the IDT for obtaining a satisfactory electric characteristic are examined.~~checked.~~ The result is shown in Fig. 16.

[0126] That is, the number of electrode fingers of the IDTs except for the electrode fingers of the narrow pitch electrode finger section, for example in~~,~~ the IDTs 4a to 4c of the above-mentioned preferred embodiment~~,~~ corresponds to 22/31/22. The number of electrode fingers of the IDTs 4a to 4c except for the electrode fingers of the narrow pitch electrode finger section is adjusted and~~changed and moreover~~ the electrode finger cross width is adjusted~~changed~~ to fabricate various types of the surface acoustic wave filter 1 for measuring the VSWR. It should be noted that the IDTs 5a to 5c are similar to the IDTs 4a to 4c.

[0127] As is apparent from Fig. 16, ~~it is understood that~~ the VSWR reduced to less~~becomes smaller~~ than the value of the VSWR of 2.0 in the related-art balanced-type surface acoustic wave filter, and the range of the improvement is disclosed below.~~the following range.~~ It should be noted that hereinafter K1 denotes the number of electrode fingers of the ~~remaining~~ electrode finger section except for the electrode fingers of the narrow pitch electrode finger section N in the second IDTs 4b and 5b in the center and K2 denotes the number of electrode fingers of the ~~remaining~~ electrode finger section except for the electrode fingers of the narrow pitch electrode finger section N in the first and third IDTs 4a, 4c, 5a, and 5c.

IDT finger number	K1/K2	Cross width W range
26/29/26	1.12	46.0 to 54.0 λI
24/29/24	1.21	46.5 to 54.5 λI
22/31/22	1.41	48.5 to 54.5 λI

20/33/20	1.65	48.5 to 53.5 λI

[0128] That is, ~~it is understood~~ when $P1>P2$ and $1.12 \leq K1/K2 \leq 1.65$ are satisfied, and ~~furthermore~~ when the electrode finger cross width is set in the range of $48.5\ \lambda I \leq W \leq 53.5\ \lambda I$, acceptable film characteristics are ~~the satisfactory film characteristic can be~~ obtained.

[0129] However, ~~In the meantime however,~~ as is ~~already~~ known, when the metallization ratio is changed, the capacity is changed and~~,~~ the optimal value of the electrode finger cross width is changed. Thus, when a metallization ratio of electrode fingers except for the narrow pitch electrode finger section N is set as d, it is desirable to set the value of the electrode finger cross width W in the range of $67.4\ \lambda I \leq W/d \leq 74.3\ \lambda I$. In this manner, the balanced-type surface acoustic wave filter 1 connected to the IC with the input impedance of 100 Ω and provided with the acceptable~~satisfactory~~ film characteristics is ~~characteristic can be~~ easily provided in which the impedance of the unbalanced input terminal 3 can be precisely set to 50 Ω and the impedances of the balanced output terminals 7 and 9 can be precisely set to 100 Ω~~Ω with precision~~.

[0130] In particular, in the above-described preferred ~~mentioned~~ embodiment, not only the number~~log~~ of the electrode fingers, that is, the number of electrode fingers, but also the electrode finger pitches P1 and P2 of the narrow pitch electrode finger sections are changed, and therefore the impedance ratio between the impedance of the unbalanced input terminal 3 and the

impedances of the balanced output terminals 7 and 9 can be precisely set to about 1:2~~ with precision~~.

[0131] It should be noted that although K1n=K2n is satisfied in this preferred embodiment, the number of electrode fingers K1n of the narrow pitch electrode finger section of the second IDT 4b and 5b connected to the unbalanced signal terminal should not necessarily be equal to the number of electrode fingers K2n of the narrow pitch electrode finger section of the first and second IDTs 4a, 4c, 5a, and 5c connected to the balanced signal terminal. However~~In the meantime however~~, as described above, with the setting of K1n=K2n, ~~it is put into a preferable condition where~~ the design~~designing~~ of the IDT is facilitated, and at the same time, the effect provided by the narrow pitch electrode finger section of suppressing the discontinuity in the area where the IDTs are located adjacent is ~~can be~~ further enhanced.

~~(~~Second Preferred Embodiment~~)~~

[0132] A balanced-type surface acoustic wave filter having the same electrode configuration~~construction~~ as the balanced-type surface acoustic wave filter 1 of the first preferred embodiment is fabricated. It should be noted that the electrode configuration ~~construction~~ is preferably the same as that of the first preferred embodiment, and, hereinafter, reference numerals of the respective components of the surface acoustic wave filter according to the second preferred embodiment

are the same as in the case of the surface acoustic wave filter 1 ~~while incorporating Fig. 1~~.

[0133] The configuration of ~~construction of~~ the surface acoustic wave filter according to the second preferred embodiment is preferably the same as that of the surface acoustic wave filter according to the first preferred embodiment except for the following three points.

[0134] (1) The number~~log~~ of the electrode fingers of the IDTs 4a to 4c and 5a to 5c: 22 (5)/(3) 31 (3)/(5) 22, where the number of electrode fingers in brackets represents the number of electrode fingers of one narrow pitch electrode finger section and the number of electrode fingers outside the brackets represents the number of electrode fingers of the IDT except for the narrow pitch electrode finger section. The number of electrode fingers of the IDTs 5z to 5c is ~~set~~ equal to that of the IDTs 4a to 4c.

[0135] (2) The pitch P1 of the narrow pitch electrode finger section N of the second IDT 4b and 5b=0.437 λI

[0136] (3) The electrode finger pitch P2 of the narrow pitch electrode finger section N of the first and third IDTs 4a, 4c, 5a, and 5c=0.462 λI

[0137] That is, the number of electrode fingers N2 of the narrow pitch electrode finger section N of the IDTs 4a and 4c, 5a, and 5c connected to the balanced output terminals 7 and 9 is greater~~set larger~~ than the number of electrode fingers N1 of the narrow pitch electrode finger section N of the IDTs 4b and 5b

connected to the unbalanced input terminal 3, and at the same time, the electrode finger pitch P2 is greater~~set larger~~ than the electrode finger pitch P1.

[0138] ~~——~~Figs. 17 and 18 show an attenuation frequency characteristic and a VSWR characteristic of the surface acoustic wave filter according to the second preferred embodiment, and Figs. 19A~~(a)~~ and 19B~~(b)~~ are Smith charts showing a reflection characteristic on the S11 side and a reflection characteristic on the S22 side.

[0139] ~~——~~As is apparent from the comparison between Figs. 5 to 7B and Figs. 17 to 19B, in the second preferred embodiment, the maximum insertion loss in the pass band of the DCS reception filter is about 1.96 dB and the maximum value of the VSWR is about 1.90. Therefore, compared with the characteristics shown in Figs. 5 to 7B~~7 as the comparison example~~, according to the second preferred embodiment, the maximum insertion loss in the pass band is ~~can be~~ reduced by~~to~~ about 0.20 dB, and ~~it is thus understood that~~ the VSWR is ~~can be~~ reduced by about 0.10~~ as well~~.

[0140] ~~——~~In the second preferred embodiment, the reason why the filter characteristic is improved as compared with the above-mentioned comparison example is as follows. As is apparent from the reflection characteristics of Figs. 11A~~(a)~~ and 11B, in order ~~(b) used~~ for ~~explaining the principle of the above embodiments to be described below, in order that~~ the impedance on the S11 side to be ~~is~~ set high, the impedance of the S22 side is set low, and the number of electrode fingers of the IDT may be changed. From

the reflection characteristics shown in Figs. 11A and 11B~~. 11~~, Figs. 20A~~(a)~~ and 20B~~(b)~~ show the reflection characteristics on the S11 side and the S22 side when the number of electrode fingers of the narrow pitch electrode finger section N connected to the balanced output terminals 7 and 9 is increased from 3 to 5. As is apparent from Figs. 20A and 20B~~20, with the change~~, it is understood that the resonance B approaches~~is approaching~~ the impedance matching point in the reflection characteristics on both of the S11 side and the S22 side. That is, the impedance of the resonance B, which cannot be adjusted by only changing the number of electrode fingers of the IDT, can be adjusted by changing the number of electrode fingers of the narrow pitch electrode finger section N of the IDTs 4a, 4c, 5a, and 5c connected to the balanced output terminals 7 and 9. Then, eventually, the number of electrode fingers of the narrow pitch electrode finger sections N of the IDTs 4a to 4c and 5a to 5c ~~respectively~~ connected to the unbalanced input terminal 3 and the balanced output terminals 7 and 9 are optimized, thereby obtaining the characteristics of the second preferred embodiment described above.

[0141] As described above, in the second preferred embodiment, the second IDT of the longitudinally coupled resonator type surface acoustic wave filter sections 4 and 5 is connected to the unbalanced input terminal 3, the IDTs 4a and 4c, and 5a and 5c on both ~~the~~ sides thereof are respectively connected to the first and second balanced output terminals 7 and

9, whereby in the surface acoustic wave filter provided with a balance-unbalance conversion function, with the configuration in which ~~it is understood that with the construction for satisfying~~ N1<N2 and P1<P2 are satisfied, ~~, it is possible to provide~~ a surface acoustic wave filter is provided in which not only the impedance ratio between the unbalanced input terminal 3 and the balanced output terminals 7 and 9 can be set to about 1:2, but also, the insertion loss and the VSWR in the pass band are greatly improved~~superior~~.

[0142] ~~——~~It should be noted that P1<P2 is satisfied in this preferred embodiment, however, ~~but~~ if P1≠P2 is satisfied, similar to ~~set, similarly to~~ this preferred embodiment, while ensuring the satisfactory film characteristic, the impedance ratio between the unbalanced input terminal 3 and the balanced output terminals 7 and 9 can be set to about 1:2. However~~In the meantime however~~, preferably, as described above, when P1<P2 is satisfied, the VSWR in the pass band is ~~can be made~~ further reduced~~smaller~~.

~~(~~Other Preferred Embodiments~~)~~

[0143] ~~——~~In the first and second preferred embodiments, for the impedance adjustment, the ~~method of setting the~~ electrode finger pitch P1 of the second IDTs 4b and 5b connected to the unbalanced input terminal 3 is set to be different from the electrode finger pitch P2 of the narrow pitch electrode finger section N of the IDTs 4a and 4c, and 5a and 5c connected to the balanced output terminals 7 and 9. However, ~~, but~~ another

impedance adjustment method of setting the IDT duty different for every IDT may be used in combination therewith~~as well~~.

[0144] Then, in the first and second preferred embodiments, the surface acoustic wave filter 1 provided with the balance-unbalance conversion function is configured to include ~~constructed where~~ three IDTs~~ are provided~~, the second IDT 4b and 5b located in the center are connected to the unbalanced input terminal, and the IDTs 4a, 4c, 5a, and 5c located on the left and right sides are connected to the balanced output terminals 7 and 9. However, the present invention is not limited to the surface acoustic wave filter 1 provided with the balance-unbalance conversion function of such an electrode construction. Figs. 21 to 23 show schematic plan views of~~showing~~ an electrode configuration of ~~construction~~ a surface acoustic wave filter according to third to ~~the~~ fifth preferred embodiments~~embodiment~~ of the present invention.

[0145] As shown in Fig. 21, in a balanced-type surface acoustic wave filter 31 of a third preferred embodiment, the first and second longitudinally coupled resonator type surface acoustic wave filter sections 34 and 35 are connected to an unbalanced input terminal 33. The surface acoustic wave filter sections 34 and 35 are constructed similarly to the surface acoustic wave filter sections 4 and 5 of the surface acoustic wave filter 1 according to the first preferred embodiment. However~~In the meantime however~~, in the surface acoustic wave filter section 34, first and third IDTs 34a and 34c on both the

sides of the surface acoustic wave propagating direction are connected to an unbalanced input terminal 33. Then, a second IDT 34b located in the center is electrically connected to a first balanced output terminal 37 via a 1-port type surface acoustic wave resonator 36. Reflectors 34d and 34e are arranged on both ~~the~~ sides in the surface acoustic wave propagating direction of the area where the IDT 34a to 34c are provided. The 1-port type surface acoustic wave resonator 36 is similar~~constructed similarly~~ to the 1-port type surface acoustic wave resonator 6.

[0146] In the surface acoustic wave filter section 35~~ as well~~, first and third IDTs 35a and 35c on both ~~the~~ sides are connected to an unbalanced input terminal 33, a second IDT 35b is connected to a second balanced output terminals 39 via a 1-port type surface acoustic wave resonator 38. That is, in the surface acoustic wave filter 31, the first and third IDTs 34a, 34c, 35a and 35c in the surface acoustic wave propagating direction are electrically connected to the unbalanced input terminal 33 and the second IDT in the center 34b and 35b are electrically connected to the first and second balanced output terminals 37 and 39.

[0147] In this case~~ as well~~, as in the first preferred embodiment, when the electrode finger pitch of the narrow pitch electrode finger section of the IDT 34a, 34c, 35a and 35c connected to the unbalanced input terminal 33 is set as P1, an electrode finger pitch of the narrow pitch electrode finger section of the IDT 34b and 35b connected to the balanced output

terminals 37 and 39 is set as P2, the number of electrode fingers of the electrode finger section except for the narrow pitch electrode finger section of the IDT 34a, 34c, 35a and 35c connected to the unbalanced input terminal 33 is set as K1, the number of electrode fingers of the narrow pitch electrode finger section thereof is set as K1n, the number of electrode fingers of the electrode finger section except for the narrow pitch electrode finger section of the IDT 34b and 35b connected to the balanced output terminals 37 and 39 is set as K2, and the number of electrode fingers of the narrow pitch electrode finger section thereof is set as K2n, by setting of P1>P2 and 1.12≤K1/K2≤1.65, and ~~then~~ more preferably by setting of K1n=K2n, ~~it is possible to provide~~ the balanced-type surface acoustic wave filter is provided in which the insertion loss and the VSWR in the pass band are greatly reduced~~small~~, the filter characteristic is satisfactory, and at the same time the impedance ratio between the unbalanced input terminal and the balanced output terminals 37 and 39 is set to about 1:2.

[0148] It should be noted that in the third preferred embodiment~~ as well~~, preferably, ~~, furthermore~~ while the metallization ratio of the first and second surface acoustic wave filter sections 34 and 35 is set to d and an electrode finger cross width is set as W, in the case where 67.4 λI≤W/d≤74.3 λI is satisfied and therefore the impedance on the unbalanced input terminal 33 side is set to 50 **Ω**, the output impedance on the side of the balanced output terminals 37 and 39 can be easily set

to 100 Ω.

[0149] Then, in the third preferred embodiment ~~too~~, as in the second preferred embodiment, $P1 \neq P2$ is set, and preferably, $P1 < P2$ is set. When the number of electrode fingers of the narrow pitch electrode finger section of the IDT 34a, 34c, 35a and 35c connected to the unbalanced input terminal 33 is set as N1 and the number of electrode fingers of the narrow pitch electrode finger section of the IDTs connected to the first and second balanced output terminals 37 and 39 is set as N2, by setting $N1 < N2$, the degree of freedom for adjusting impedances of a plurality of resonant modes is greatly ~~can be~~ increased. Therefore, the insertion loss and the VSWR in the pass band are reduced~~small~~, and not only the satisfactory film characteristic is obtained,~~attained~~ but also the impedance ratio between the unbalanced input terminal 33 and the balanced output terminals 37 and 39 can be set to about 1:2.

[0150] Fig. 22 is a schematic plan view showing an electrode construction of a surface acoustic wave filter section 41 according to a fourth preferred embodiment. In the balanced-type surface acoustic wave filter 41 of the fourth preferred embodiment, five IDTs 42a to 42e are arranged along the surface acoustic wave propagating direction. Reflectors 42f and 42g are arranged on both ~~the~~ sides in~~of~~ the surface acoustic wave propagating direction of ~~in~~ an area where the IDTs 42a to 42e are arranged. The IDTs 42a to 42e includes the narrow pitch electrode finger sections N similarly to the IDTs 4a to 4c. That

is, in a pair of IDTs adjacent to each other in the surface acoustic wave propagating direction with a gap interposed therebetween, a pitch of electrode fingers of a portion~~part~~ of electrode fingers including electrode fingers facing the gap is less~~made smaller~~ than an electrode finger pitch of the remaining IDTs.

[0151] In the surface acoustic wave filter section 41, the IDTs 42a, 42c, and 42e are connected to an unbalanced input terminal 43. Then, the IDTs 42b and 42d are respectively electrically connected to the first and second balanced output terminals 47 and 49. In the surface acoustic wave filter section 4 provided with such a balance-unbalance conversion function, when the electrode finger pitch of the narrow pitch electrode finger section N of the IDTs 42a, 42c, and 42e connected to the unbalanced input terminal 43 is set as P1, the number of electrode fingers of the narrow pitch electrode finger section N thereof is ~~set as~~ K1n, the number of electrode fingers except for the narrow pitch electrode finger section thereof is ~~set as~~ K1, the electrode finger pitch of the narrow pitch electrode finger section N of the IDTs 42b and 42d connected to the balanced output terminals 47 and 49 is ~~set as~~ P2, the number of electrode fingers of the narrow pitch electrode finger section thereof is ~~set as~~ K2n, and the number of electrode fingers except for the narrow pitch electrode finger section thereof is ~~set as~~ K2, and by setting of P1>P2 and 1.12≤K1/K2≤1.65, and preferably, by further setting of K1n=K2n, reduction in the insertion loss and

the VSWR in the pass band is achieved, and the impedance ratio between the unbalanced input terminal 43 and the balanced output terminals 47 and 49 can be set to about 1:2. Preferably, by setting of $134.8\ \lambda I \leq W/d \leq 148.6\ \lambda I$, when the impedance on the unbalanced input terminal 43 side is set to 50 Ω, the impedance on the side of the balanced output terminals 47 and 49 can be easily set to 100 Ω.

[0152] In addition, in the fourth preferred embodiment ~~too~~, as in the second preferred embodiment, ~~apart from the above,~~ by also setting ~~of~~ P2>P1 and N2>N1, the impedance ratio between the unbalanced input terminal and the balanced output terminals can be ~~set to 1:2~~ easily set to about 1:2, and at the same time, the reduction in the insertion loss and the VSWR in the pass band is ~~can be~~ achieved.

[0153] Fig. 23 is a schematic plan view showing an electrode configuration~~construction~~ of a balanced-type surface acoustic wave filter of a fifth preferred embodiment. A surface acoustic wave filter 50 according to the fifth preferred embodiment is constructed similar~~similarly~~ to the surface acoustic wave filter 41 according to the fourth preferred embodiment except that the number of the IDTs is three. That is, in a balanced-type surface acoustic wave filter 50 according to the fifth preferred embodiment, three IDT 42b to 42d are arranged along the surface acoustic wave propagating direction. Reflectors 42f and 42g are arranged on both ~~the~~ sides in~~of~~ the surface acoustic wave propagating direction of ~~in~~ an area where

the first to third IDTs 42b to 42d are provided.

[0154] Therefore, except for the omission of IDTs 42a and 42e of Fig. 22, the surface acoustic wave filter 50 is similar~~constructed similarly~~ to the surface acoustic wave filter 41. Therefore, the same reference numerals are used for~~given to~~ the same components with the incorporation of the description with respect to Fig. 22.

[0155] In this preferred embodiment~~ as well~~, by setting of P1>P2 and 1.12≤K1/K2≤1.65, and preferably, by further setting of K1n=K2n, as in the case of the fourth preferred embodiment, the reduction in the insertion loss and the VSWR in the pass band is achieved and the impedance ratio between the unbalanced input terminal 43 and the balanced output terminals 47 and 49 can be set to about 1:2. In addition~~Then~~, preferably, by setting of 134.8 λI≤W/d≤148.6 λI, when the impedance on the unbalanced input terminal 43 side is set to 50 Ω, the impedance on the side of the balanced output terminals 47 and 49 can be easily set to 100 Ω.

[0156] In addition, in the fifth preferred embodiment~~ too~~, as in the second preferred embodiment, ~~apart from the above,~~ by setting ~~of~~ N2>N1 and P2≠P1, and preferably by setting ~~of~~ N2>N1 and P2>P1~~ as well~~, the impedance ratio between the unbalanced input terminal and the balanced output terminals can be easily set to about 1:2, ~~easily~~ and at the same time, the reduction in the insertion loss and the VSWR in the pass band is ~~can be~~ achieved.

[0157] Fig. 24 is schematic plan view showing an electrode construction of a balanced-type surface acoustic wave filter of a sixth preferred embodiment. In a balanced-type surface acoustic wave filter 51 according to the sixth preferred embodiment, five IDTs 52a to 52e are arranged along the surface acoustic wave propagating direction. The IDTs 52a to 52e include the narrow pitch electrode finger sections N similar~~similarly~~ to the IDTs 42a to 42e. Reflectors~~Then, reflectors~~ 52f and 52g are arranged on both ~~the~~ sides in ~~of~~ the surface acoustic wave propagating direction of an area where the IDTs 52a to 52e are provided. It should be noted that the IDT 52c in the center includes IDT sections 52c1 and 52c2 that are divided in the surface acoustic wave propagating direction.

[0158] In this preferred embodiment, the IDTs 52b and 52d are electrically connected to an unbalanced input terminal 53. Then, IDT 52a and the IDT section 52c1 are electrically connected to a first balanced output terminal 57 and the IDT section 52c2 and the IDT 52e are electrically connected to a balanced output terminal 59, thereby providing~~realizing~~ the balance-unbalance conversion function.

[0159] In this preferred embodiment~~as well~~, when the electrode finger pitch of the narrow pitch electrode finger section N in the IDTs 52b and 52d connected to the unbalanced input terminal 53 ~~that is the unbalanced signal terminal~~ is set as P1, the number of electrode fingers of the narrow pitch electrode finger section N thereof is ~~set as~~ K1n, the number of

electrode fingers of the electrode finger section except for the narrow pitch electrode finger section is ~~set as~~ K1, the electrode finger pitch of the narrow pitch electrode finger section N of the IDTs 52a, 52c, and 52e connected to the balanced output terminals 57 and 59 is ~~set as~~ P2, the number of electrode fingers of the narrow pitch electrode finger section thereof is ~~set as~~ K2n, the number of electrode fingers of the electrode finger section except for the narrow pitch electrode finger section is ~~set as~~ K2, $P1>P2$ and $1.12 \le K1/K2 \leqq$ ~~=~~ 1.65 are satisfied, and preferably, ~~moreover~~ $K1n=K2$ is satisfied, without degrading the filter characteristic similar~~similarly~~ to the respective above-mentioned preferred embodiments, the impedance ratio between the unbalanced signal terminal and the balanced signal terminal can be set to about 1:2. In the sixth preferred embodiment~~ as well~~, preferably, $134.8\ \lambda I \le W/d \le 148.6\ \lambda I$ is satisfied, when the impedance connected to the unbalanced input terminal 53 side is set to about 50 Ω, the impedance on the side of the balanced output terminals 57 and 59 can be easily set to about 100 Ω.

[0160] In addition, in ~~Then,~~ the sixth preferred embodiment ~~too~~, as in the second preferred embodiment, $P1 \neq P2$ and $N1<N2$ are satisfied, and preferably, ~~with the construction for satisfying~~ $P1<P2$ and $N1<N2$ are satisfied. Thus, as in the second preferred embodiment, it is possible to provide the surface acoustic wave filter in which the impedance ratio between the unbalanced input terminal 53 and the balanced output terminals 57 and 59 is about 1:2, and also the insertion loss and the VSWR are reduced~~small~~ in

the pass band.

[0161] Fig. 25 is a schematic plan view showing an electrode configuration~~construction~~ of a balanced-type surface acoustic wave filter according to a seventh preferred embodiment. A surface acoustic wave filter 70 according to the seventh preferred embodiment preferably has almost the same configuration~~construction~~ as the surface acoustic wave filter 51 according to the sixth preferred embodiment shown in Fig. 24, except that the IDTs 52a and 52e are omitted. Therefore, the same reference numerals are used for~~given to~~ the same components, and the description made with reference to the sixth preferred embodiment is incorporated herein.

[0162] In this preferred embodiment, the first to third IDTs 52b to 52d are arranged along the surface acoustic wave propagating direction. Then, the second IDT in the center 52c is divided so as to have the IDT sections 52c1 and 52c2. In this preferred embodiment~~ too~~, as in the ~~case of the~~ sixth preferred embodiment, by satisfying $P1>P2$ and $1.12 \leq K1/K2 \leq 1.65$, and preferably, by further satisfying $K1n=K2n$, the impedance ratio between the unbalanced input terminal and the balanced output terminal can be set to about 1:2 without degrading the filter characteristic. In addition, in the seventh preferred embodiment ~~as well~~, preferably, by satisfying $134.8\ \lambda I \leq W/d \leq 148.6\ \lambda I$, when the impedance on the unbalanced input terminal 53 side is set to about 50 Ω, it is possible to easily set the impedance on the side of the balanced output terminals 57 and 59 to about 100 Ω.

[0163] Then, according to seventh preferred embodiment ~~too~~, as in the second preferred embodiment, with ~~the construction for satisfying~~ $P1 \neq P2$ and $N1 < N2$ being satisfied, and preferably, with~~the construction for satisfying~~ $P1 < P2$ and $N1 < N2$ being satisfied,~~, it is possible to provide~~ the surface acoustic wave filter is provided in which the impedance ratio between the unbalanced input terminal 53 and the balanced output terminals 57 and 59 is set to about 1:2 and ~~also~~ the insertion loss and the VSWR are reduced~~small~~ in the pass band.

[0164] It should be noted that in the surface acoustic wave filters 41 and 51 according to the fourth and sixth preferred embodiments, the five IDTs 42a to 42e and 52a to 52e are provided. In this manner, in the surface acoustic wave filters according to preferred embodiments of the present invention, not only the three IDTs including~~composed of~~ the first to third IDTs, but also five or more IDTs may be arranged in the surface acoustic wave propagating direction.

[0165] While preferred embodiments of the present invention have been described above, it is to be understood that variations and modifications will be apparent to those skilled in the art without departing the scope and spirit of the present invention. The scope of the present invention, therefore, is to be determined solely by the following claims.